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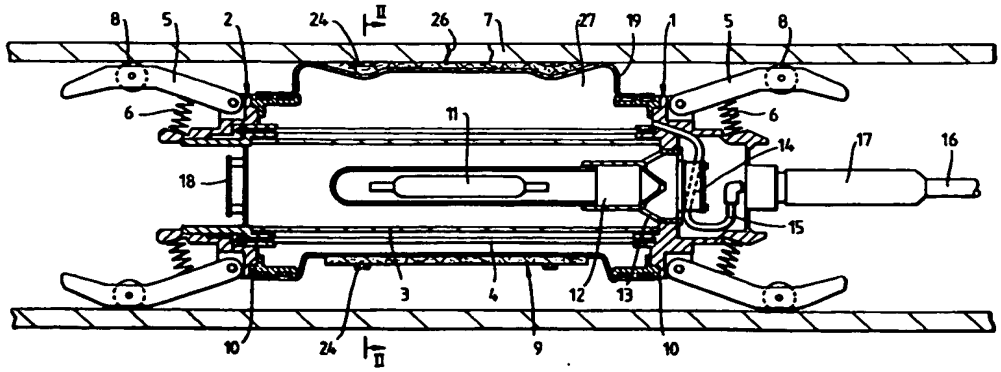
(54) Method and apparatus for repairing a pipeline.

(57) A tubular sheetlike material (21) composed mainly of a sheet material (22) formed from a thickened solution of an ultraviolet-curing resin in which high-strength fibers are dispersed, is inserted into a pipeline (7) so as to face a damaged part (26) thereof, is expanded into intimate contact with the inner surface of the pipeline (7), and is irradiated with ultraviolet light on its inner surface, whereby the resin is cured. Sealing members (24) capable of swelling with water are fitted about the opposite end portions of the tubular sheetlike material (21) so that the sealing members (24) may be located on the opposite sides of the damaged part (26) of the pipeline (7) from each other.

Fig.1.



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This invention relates to a method, apparatus, and material for repairing mainly an underground pipeline, such as a sewer.

When an underground pipeline has a damaged part or joint through which a fluid leaks out from the pipeline or underground water leaks into it, it is desirable to repair the damaged part or joint to prevent such leakage.

When repairing such a pipeline, it has been usual to repair a long pipeline as a whole by inserting a tubular lining material into the pipeline and hardening the lining material along the inner surface of the pipeline.

Methods for repairing a sewer pipe, for example, have involved applying lengthy tubular sheet material formed from a thickened solution of a curable resin in which high-strength fibers are dispersed onto the inner surface of the pipe applying pressure to the inside of the tubular sheet expanding it to bring it into intimate contact with the inner surface of the pipeline, and supplying pressurized steam into the tubular sheetlike material to heat it to cure the resin. It is particularly effective if longitudinal edges of the material overlap circumferentially (see EP-A-454309).

If a long pipeline is only partly damaged, however, it is undesirable from an economical standpoint to line the whole pipeline and it is desirable to repair only its damaged part.

The lining of only a part of a pipeline, such as a damaged part, however, presents different problems from those arising from the lining of the whole pipeline along its entire length.

For example, when lining a sewer pipe by a method as described above, a rigid pipe formed in the pipeline to line it does not necessarily adhere closely to the inner surface of the pipeline, but there is a good likelihood that a clearance may be left between the outer surface of the pipe and the inner surface of the pipeline which will allow the passage of underground water entering the pipeline through its damaged part.

If the pipeline is lined along its whole length, the underground water which has entered the clearance is required to flow a very long distance before leaving it to enter the pipeline, and the amount of water entering the pipeline is, therefore, negligible. If the pipeline is only partly lined, however, the distances between its damaged part and the ends of the lining pipe are too short to prevent a large amount of underground water from entering the pipeline and flowing into sewage.

Another problem is that there are not a few cases where the work for lining a pipeline has to be done in the presence of a large amount of underground water which has entered it through its damaged part. Therefore, it is very likely that water may hinder the curing reaction of the resin, or that the cooling action of water may delay the effective heating of the resin and its curing.

Under these circumstances, it is an object of this invention to enable the repairing of a pipeline, such as a sewer, which is limited to a damaged part thereof and, independently, to prevent underground water more effectively from entering the pipeline through its damaged part and past a comparatively short repair pipe.

According to a first aspect of this invention, there is provided a method of repairing a pipeline which comprises inserting a roll of a sheet-like material including a thickened solution of an ultraviolet-curing resin in which high-strength fibers are dispersed, and having a pair of longitudinal edge portions slidably overlapping each other, into a damaged part of the pipeline, causing its overlapping portions to slide on each other to expand the tubular sheetlike material and bring it into intimate contact with the inner surface of the pipeline, and irradiating the tubular sheetlike material with ultraviolet light from an ultraviolet lamp within the pipeline to cure the resin.

According to a second aspect of this invention, there is provided a method of repairing a pipeline which comprises inserting a roll of a sheet material including a thickened solution of a curable resin in which high-strength fibers are dispersed and having a pair of longitudinal edge portions slidably overlapping each other hand having sealing materials capable of swelling with water on the outer surface of the tubular sheetlike material at least adjacent to both ends thereof, into a damaged part of the pipeline, causing its overlapping portions to slide on each other to expand the tubular sheetlike material and bring it into intimate contact with the inner surface of the pipeline, with the sealing materials sandwiched between the outer surface of the tubular sheetlike material and the inner surface of the pipeline so that at least one sealing material is located on each longitudinal side of the damaged part of the pipeline and curing the resin.

This invention also provides an apparatus which is used for carrying out the method according to the first aspect of this invention, and which comprises a tubular member transmitting ultraviolet light, supporting members attached to both ends of the tubular member for supporting it against the inner surface of a pipeline, while being movable along the pipeline, mounts for a repairing material which are provided around the both ends of the tubular member for mounting both ends of the repairing material fitted around the tubular member, pressurizing means for supplying a pressurized fluid into the space between the tubular member and the mounts and an ultraviolet lamp positioned within the tubular member. There is preferably also a cooling fan for supplying air into the tubular

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member to cool the ultraviolet lamp.

This invention also provides a repairing material which may be employed in the apparatus as defined above for lining a pipeline by the method according to the first aspect of this invention, and which material comprises a flexible and inflatable tube transmitting ultraviolet light, the said tubular sheetlike material about the inflatable tube, the repairing material being enclosed in a bag opaque to ultraviolet light.

The repairing material may further include annular sealing members fitted to the outer surface of the tubular sheetlike material adjacent to both ends thereof, the sealing members being of a material which swells by absorbing water, so that it may also be employed for carrying out the method according to the second aspect of this invention.

Embodiments of the different aspects of the invention will now be described with reference to drawings wherein:

Figure 1 is a diametrical sectional view of an apparatus embodying this invention with repair material shown in two different positions;

Figure 2 are sectional views taken along the line II-II of Figure 1, and showing (a) the apparatus as positioned in a pipeline, and (b) an expanded repairing material, respectively; and

Figure 3 is a perspective view of repairing material embodying this invention.

Figure 1 shows an apparatus embodying this invention which includes supporting members 1 and 2, and a tubular member 3 formed from a material transmitting ultraviolet light, such as quartz glass, and connected between the supporting members 1 and 2. The supporting members 1 and 2 are connected to each other by connecting rods 4.

Each of the supporting members 1 and 2 is provided with a plurality of pivotally-mounted legs 5 which are urged by spring means 6 outwardly toward an open position, and each leg 5 is provided with a roller 8 for contacting the inner surface of a pipeline 7.

Each supporting member 1 or 2 is provided with an annular mount 10 for repairing material 9 which will hereinafter be described.

The rear supporting member 1 is provided with a socket 12 for an ultraviolet lamp 11 positioned within the tubular member 3.

The supporting member 1 has a through hole 13 in its portion to which the socket 12 is attached, and a fan 14 is installed behind the socket 12 for supplying air into the tubular member 3 through the hole 13 to cool the ultraviolet lamp 11.

An air supply pipe 15 is employed as pressurizing means for supplying compressed air into the space between the tubular member 3 and the mount 10 for the repairing material, through the supporting member 1.

A cable 16 is attached to the rear supporting member 1 by a connector 17, and holds the air supply pipe 15 and an electric wire for supplying electricity to the ultraviolet lamp 11 and the cooling fan 14, its other end being located outside the pipeline 7.

The front supporting member 2 has a cover 18 for preventing water, etc. from entering the tubular member 3.

The repairing material 9, which is tubular, is fitted about the tubular member 3 and has its opposite ends fastened to the mounts 10 on the supporting members 1 and 2, respectively, as shown in Figure 1. Figure 1 shows in its lower half the repairing material 9 as fitted in the apparatus, while its upper half shows the repairing material 9 expanded by compressed air supplied into the space between it and the tubular member 3, and brought into contact with the inner surface of the pipeline 7.

The repairing material 9 is shown in detail in Figure 3. It comprises a flexible and inflatable tube 19 formed from a plastics material transmitting ultraviolet light.

A sheetlike material 20 is rolled around the inflatable tube 19 and forms a tubular structure 21. The sheetlike material 20 is composed mainly of a sheet material 22 formed from a thickened solution of an ultraviolet-curing resin in which high-strength fibers are dispersed, and includes a thin meshed woven fabric 23 of glass fibers bonded to the outer surface of the sheet material 22 and forming an integral part thereof, as shown in Figure 3.

This arrangement is, however, not intended to limit the scope of this invention. This invention does not preclude the use of a woven fabric of a synthetic fiber, such as polyester fiber, instead of the woven fabric 23 of glass fibers. Moreover, the woven fabric 23 need not necessarily be provided on the outer surface of the sheet material 20, but can alternatively be located on the inner surface of the sheet material 20, or between its inner and outer surfaces.

The sheetlike material 20 may consist solely of the sheet material 22, but as the sheet material is formed merely from a thickened resin solution containing fibers dispersed therein, it is so low in strength before curing that the tubular sheetlike material 21 is likely to be excessively partially stretched, or broken when it is diametrically expanded. Therefore, the sheetlike material 20 is preferably reinforced by the woven fabric 23.

The sheetlike material 20 has a width which is somewhat larger than the inner peripheral length of the pipeline 7, and the tubular structure 21 formed by winding it about the inflatable tube 19 has a pair of longitudinal edge portions 20',20" slidably over-

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lapping each other.

The inflatable tube 19 has a pair of ends projecting from the ends, respectively, of the tubular structure material 21.

Annular sealing members 24 are fitted about the tubular structure 21 adjacent to its ends, respectively.

The sealing members are formed from a material which swells and increases its volume drastically by absorbing water, and generates pressure if its deformation is restrained by an external force. An appropriate material can be selected from among a variety of commercially available rubbers having the property of swelling or expanding with water. It will normally be pre-cured; that is, not one intended to be cured by the action of the ultraviolet lamp.

Examples of the known materials comprise crystalline diene rubbers and resins having a high water absorbency. Examples of the crystalline diene rubbers are the blends of chloroprene rubber and rubbers obtained by the random copolymerization of styrene and dienes, and examples of the resins having a high power of absorbing water include crosslinked polyacrylates, crosslinked salts of copolymers of isobutylene and maleic anhydride, and crosslinked salts of copolymers of polyvinyl alcohol and acrylic acid. Typical swelling times are in the order of 10 hours and the materials may have a swelling capacity of up to 500%.

The repairing material 9 is enclosed in a bag 25 opaque to ultraviolet light, until it is used for lining work.

A method for repairing a damaged part 26 of the pipeline 7 with the repairing material 9 employing the apparatus as hereinabove described, is as follows.

The repairing material 9 is removed from the bag 25, and put on about the tubular member 3, and the opposite ends of the inflatable tube 19 are fitted about the mounts 10 on the supporting members 1 and 2, respectively, and fastened thereto in a gastight fashion. The tubular member 3 and the repairing material 9 define a gastight closed space therebetween.

It is alternatively possible within the scope of this invention to put the inflatable tube 19 on about the tubular member 3, fit the opposite ends of the inflatable tube 19 about the mounts 10 on the supporting members 1 and 2, fasten them to the mounts 10 in a gastight fashion, and then wind the sheetlike material 20 about the inflatable tube 19.

Then, the apparatus is inserted into the pipeline 7 through one end thereof, and moved along the pipeline 7 by e.g. a cable pulling the apparatus toward the other end of the pipeline.

The legs 5 are urged outwardly of the supporting members 1 and 2 and remain in contact with the inner surface of the pipeline 7 to hold the apparatus substantially in the center of cross-section of the pipeline 7, while allowing the apparatus to move along the pipeline 7, as the rollers 8 roll on its inner surface.

When the apparatus has arrived at the damaged part 26 of the pipeline 7, it is so positioned that the damaged part 26 may be situated between the sealing members 24 on the repairing material 9. This position is shown in the lower half of Figure 1 and Figure 2(a).

Then, a pressurized fluid, such as compressed air, is supplied from a source of supply outside the pipeline 7 into the space 27 between the tubular member 3 and the repairing material 9 through the cable 16 and the air supply pipe 15.

The resulting increase in internal pressure of the inflatable tube 19 inflates it, and thereby expands the tubular sheetlike material 21 wound about it, as the overlapping portions of the sheetlike material 20 slide on each other, while the sealing members 24 fitted about the tubular sheetlike material 21 are also diametrically expanded.

The tubular sheetlike material 21 is brought into intimate contact with the inner surface of the pipeline 7, while the sealing members 24 are held between the outer surface of the tubular sheetlike material 21 and the inner surface of the pipeline 7 on the opposite side of the damaged part 26 from each other, as shown in the upper half of Figure 1 and Figure 2(b).

The ultraviolet lamp 11 is supplied with an electric current to emit ultraviolet light for irradiating the sheetlike material 20 through the tubular member 3 and the inflatable tube 19 to cure the ultraviolet-curing resin in the sheet material 22.

The fan 14 is placed in operation for supplying air into the tubular member 3 to cool the ultraviolet lamp 11 heated by the emission of ultraviolet light and thereby protect the inflatable tube 19 and the tubular sheetlike material 21 from being overheated.

When the tubular sheetlike material 21 has been fully hardened, the supply of electric current to the ultraviolet lamp 11 is discontinued, and a reduced pressure is created in the space 27 to allow the detachment of the inflatable tube 19 from the inner surface of the hardened tubular sheetlike material 21 and the removal of the apparatus from the pipeline 7.

The damaged part of the pipeline 7 is, thus, repaired with the repairing material 9 which prevents the leakage of a fluid from the pipeline and of underground water thereinto.

If the damaged part 26 of the pipeline 7 forms a missing part of its wall, it is likely that the sheetlike material 20 may expand into the missing part to the extent that its overlapping portions form

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an opening therebetween. It is, therefore, desirable to place about the sheetlike material 20 in a tubular fabric or net which is not undesirably expanded by the internal pressure, but can hold the sheetlike material 20 against any undesirable expansion resulting in its overlapping portions forming an opening therebetween.

The method according to the first aspect of this invention relies upon ultraviolet light for curing the sheetlike material 20, instead of heating it, and can, therefore, cure it rapidly. Moreover, it ensures the efficient curing of the ultraviolet-curing resin, even if underground water may enter the damaged part 26, since the resin employed does not have its curing reaction hindered by water.

There is known a method of lining the whole of a long pipeline which employs ultraviolet light for curing a resin as a lining material. This method, however, requires a very long time for a lining job, since it is necessary to move an ultraviolet lamp very slowly along the lining material held against the inner surface of the pipeline.

It is, therefore, much lower in efficiency than a lining method which employs heating, e.g. steam heating for curing, as far as the lining of a long pipeline is concerned. If the pipeline is to be partly repaired, as contemplated by this invention, however, it is possible to accomplish its repair very quickly and efficiently, since it is sufficient to apply ultraviolet light to the lining material positioned near the part to be repaired.

The method according to the second aspect of this invention employs the sealing members 24 interposed between the outer surface of the pipeline 7 adjacent to the opposite ends of the repairing material 9 held. In the event that underground water enters the clearance between the tubular structure 21 and the pipeline 7 through the damaged part 26, it is absorbed by the sealing members 24 and swells them.

The swollen sealing members 24 have softened surfaces making intimate contact with the surfaces of the tubular structure 21 and the pipeline 7, and are restrained against deformation by the cured tubular structure 21 and the pipeline 7, resulting in the generation of pressure which forces the sealing members 24 against the tubular structure 21 and the pipeline 7.

Thus, the swollen sealing members 24 form a seal between the tubular structure 21 and the pipeline 7 against any further leakage of underground water, and maintain their sealing actions without being collapsed by the pressure of underground water.

The method according to the second aspect of this invention also enables the use of a thermosetting resin for forming the sheet material 22. Although the water leaking in through the damaged part 26 may hinder the curing of a thermosetting resin in the surface of the tubular sheetlike material 21, it is possible to achieve a satisfactory repairing job even if the surface of the tubular sheetlike material is not satisfactorily cured, since most of the tubular structure 21 is completely cured and has a sufficiently high strength, and the swollen sealing members 24 shut off water from entering the pipeline.

While it is necessary to fit the sealing members 24 about the tubular structure 21 at least adjacent to the opposite ends thereof, it is possible to employ a sealing member or members 24 covering the whole surface of the tubular structure 21. The sealing member or members 24 are interposed between the whole inner surface of the repaired part of the pipeline 7 and the whole outer surface of the tubular structure 21, and exhibits a sealing action by absorbing water along the whole length of the repairing material.

It is preferable to combine the methods according to the first and second aspects of this invention by using an ultraviolet-curing resin for the sheet material 22, and fitting the sealing members 24 about the tubular structure 21, as stated above in the description of the embodiments.

This invention makes it possible to repair a damaged part of a long pipeline, such as a sewer pipe, without lining the pipeline along its whole length, and thereby shut off underground water effectively from entering the pipeline through its damaged part.

Even if underground water may be flowing into the pipeline through its damaged part during the work for repairing, it is possible to repair the damaged part 26 and shut off underground water from flowing into the pipeline, since the method according to the first aspect of this invention employs the ultraviolet-curing resin which is curable even in the presence of water, and the method according to the second aspect thereof employs the sealing members 24 which swell with water.

Claims

1. A method of repairing a pipeline which comprises inserting a tubular structure (21) of a sheet material (20,22) including a thickened solution of an ultraviolet-curing resin in which high-strength fibers are dispersed and having a pair of longitudinal edge portions (20',20") slidably overlapping each other into a damaged part (26) of said pipeline (7), causing said overlapping portions to slide on each other to expand said tubular structure (21) and bring it into intimate contact with the inner surface of said pipeline (7), and irradiating said tubular structure (21) with ultraviolet light from an ul-

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traviolet lamp (11) positioned between the ends of the structure, to cure said resin.

2. A method according to claim 1 which includes expanding an inner inflatable layer (19) of the structure (21) by fluid pressure to cause the said expansion of the structure (21), the irradiating being through the inflatable layer (19).

3. A method of repairing a pipeline which comprises inserting a tubular structure (21) of a sheet material (20,22) including a thickened solution of a curable resin in which high-strength fibers are dispersed, having a pair of longitudinal edge portions (20',20") slidably overlapping each other, and sealing materials (24) capable of swelling with water on the outer surface of said tubular structure material (21) at least adjacent to both ends thereof, into a damaged part (26) of said pipeline (7), causing said overlapping portions to slide on each other to expand said tubular structure (21) and bring it into intimate contact with the inner surface of said pipeline (7), while sandwiching said sealing materials (24) between the outer surface of said tubular structure (21) and the inner surface of said pipeline (7) so that at least one sealing material (24) may be located on each longitudinal side of said damaged part (26) of said pipeline (7), and curing said resin.

4. An apparatus for repairing a pipeline which comprises a tubular member (3) capable of transmitting ultraviolet light, supporting members (1,2) attached to both ends of said tubular member (3) for supporting said tubular member (3) against the inner surface of a pipeline (7), while being movable along said pipeline, mounts (10) for a repairing material which are provided around the both ends of said tubular member (3) for mounting both ends of said repairing material (9) fitted around said tubular member (3), pressurizing means (15) for supplying a pressurized fluid into the space between said tubular member (3) and said mounts (10), and an ultraviolet lamp (11) positioned within said tubular member (3).

5. Apparatus according to claim 4 which also includes a fan (14) for supplying air into said tubular member (3) to cool said ultraviolet lamp (11).

6. A material for repairing a pipeline which comprises a flexible and inflatable tube (19) transmitting ultraviolet light, and a tubular structure (21) formed by a sheetlike material (20) wound about said inflatable tube (19) and having a pair of longitudinal edge portions (20',20") slidably overlapping each other, said sheetlike material (20) being composed mainly of a sheet material (22) formed from a thickened solution of an ultraviolet-curing resin in which high-strength fibers are dispersed, said sheetlike material (20) having a width which is somewhat larger than the inner peripheral length of the pipeline (7) for which it is intended, said repairing material being enclosed in a bag (25) opaque to ultraviolet light.

7. A material for repairing a pipeline according to claim 5, further including annular sealing materials (24) fitted to the outer surface of said tubular sheetlike material (21) at least adjacent to both ends thereof, said sealing materials being of a material which swells by absorbing water.

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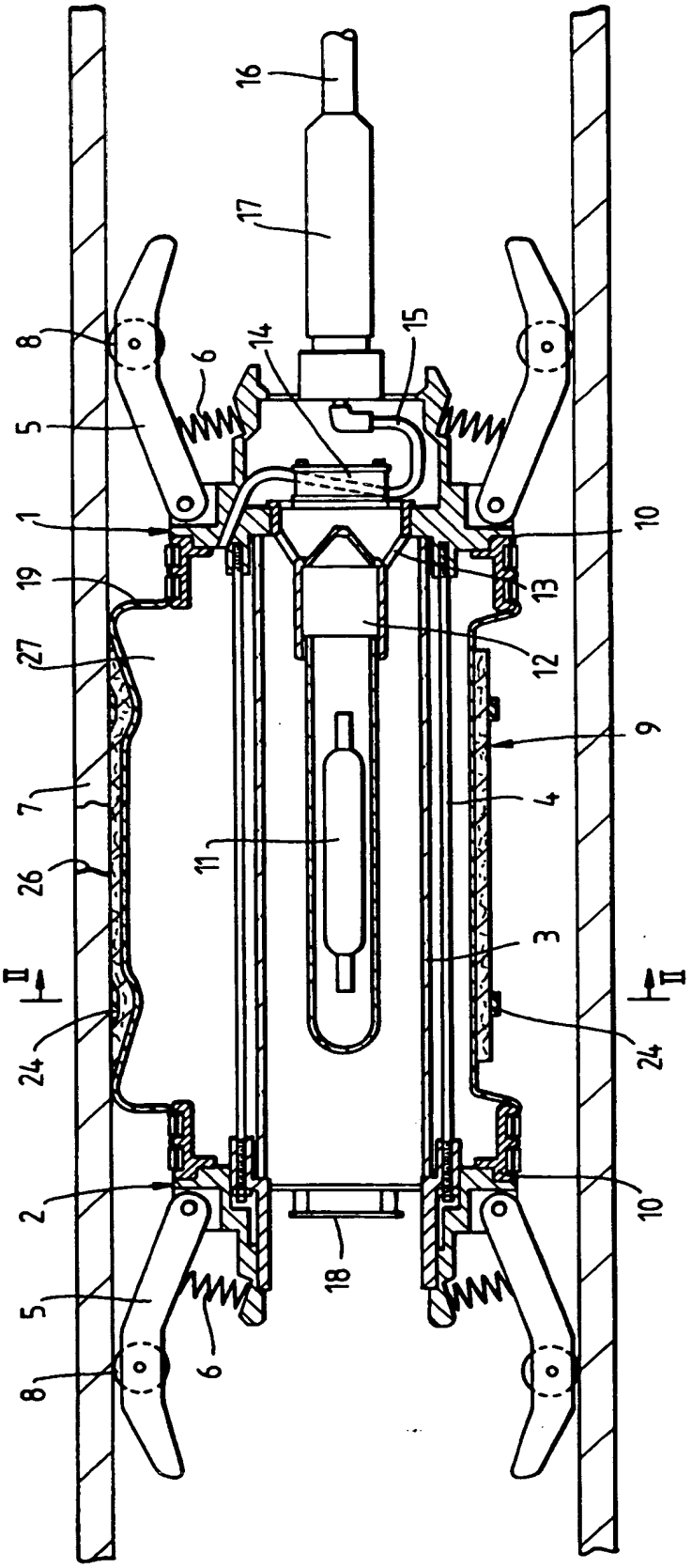

Fig.1.

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Fig. 2.

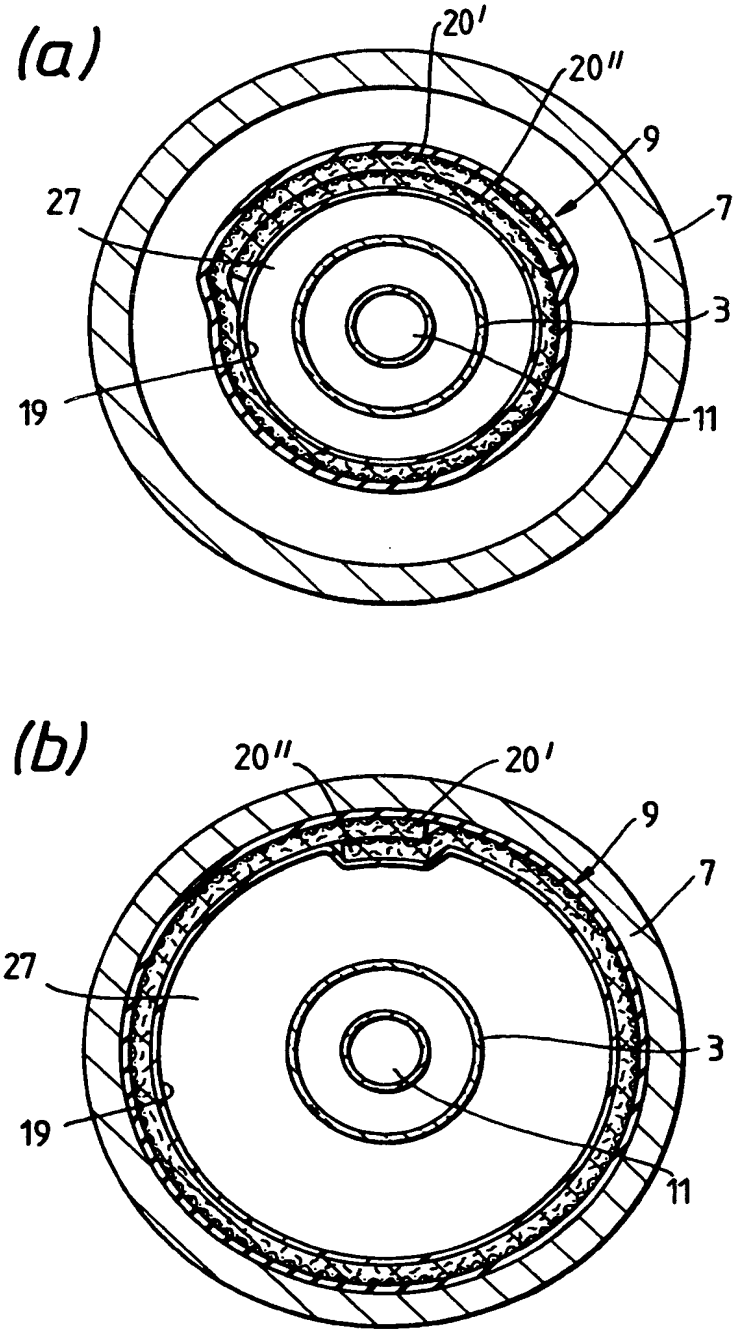

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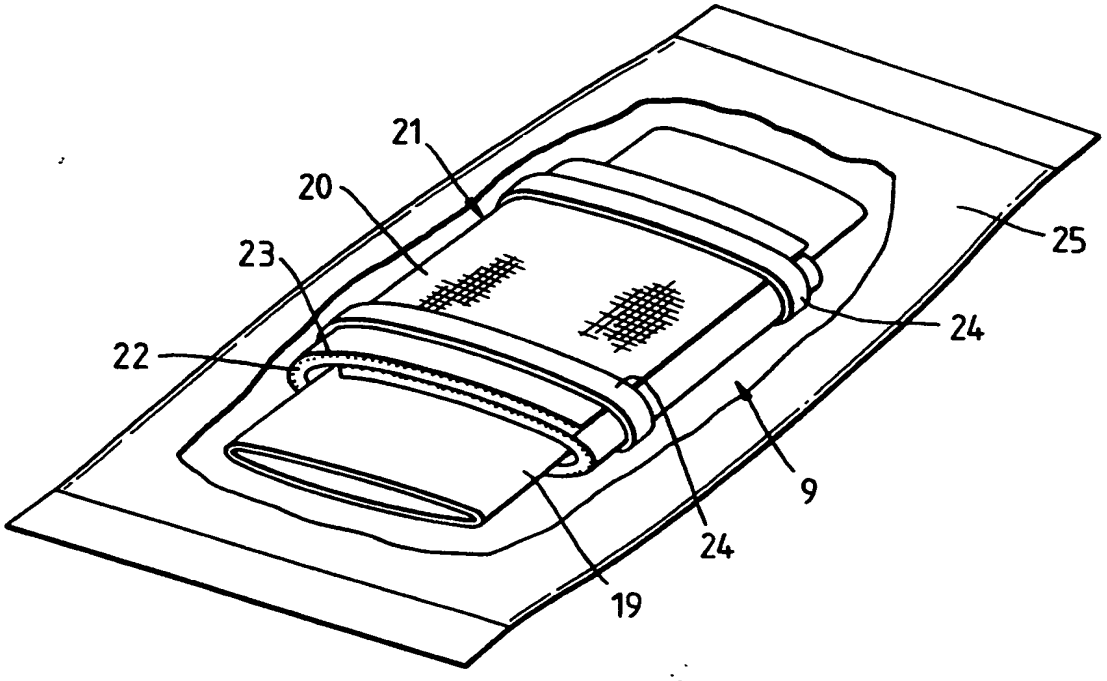
Fig.3.



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EUROPEAN SEARCH REPORT

Application Number
EP 92 31 0823

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	US-A-5 042 532 (F.W. GILLELAND) * claims; figures *	1,2,4	F16L55/162
A	DATABASE WPIL Section Ch, Week 8836, Derwent Publications Ltd., London, GB; Class A11, AN 88-254756 & JP-A-63 186 744 (SHOWA HIGH POLYMER KK.) * abstract *	1	
A	GB-A-2 172 370 (BRITISH GAS CORP.) * claim 1; figures *	1	
A	GB-A-1 363 380 (WEGNER & CO.) * figure *	4	
A	DE-A-4 021 456 (H. MÜLLER) * claim 1; figures *	4	
A	PATENT ABSTRACTS OF JAPAN vol. 12, no. 471 9 December 1988 & JP-A-63 194 929 (OSAKA BOSUI CONSTR. CO. LTD.) * abstract *	3	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

F16L

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	21 JUNE 1993	BUDTZ-OLSEN A.

CATEGORY OF CITED DOCUMENTS

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